THE NERVOUS SYSTEM IN GONIONEMA MURBACHII.

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Some physiological work which I undertook this summer at the Woods Hole Biological Laboratory on the Hydromedusa, Gonionema Murbachii, made it important that I should know the distribution of its nervous system which at the time had not been described or known with certainty. I decided, therefore, to gain some knowledge of the distribution of its nerves by means of Bethe's methylene-blue method. Inasmuch as my time for this work at Woods Hole was very limited, I was unable to undertake an exhaustive histological study of the whole nervous system of the medusa. Believing it of some interest to make known the facts that were obtained, it was decided to publish them in a brief preliminary report, hoping in the near future to see the subject completed by Mr. Chas. G. Rogers who has consented to make a detailed histological study of the distribution of the nerves, in connection with some work which he is pursuing on regeneration in this animal, under the direction of Dr. Loeb.

All my observations were made on fresh material. The whole or small parts of the animal were exposed six or more hours to the action of a weak sea-water solution of Bx methylene blue freshly made and filtered for each study. The material was kept in a cool place and transferred for study from methylene blue to sea-water or a $m/8$ solution of sodium chloride. Some material was kept for future study as long as twenty-four hours on ice in 10 per cent. ammonium molybdate to which a few drops of 1 per cent. osmic acid and hydrogen peroxide had been added (1 gm. ammonium molybdate, 10 c.c. distilled water, 1 c.c. hydrogen peroxide, two drops 1 per cent. osmic acid).

Small pieces were dissected from different regions and examined with an oil immersion lens. The study of these sections disclosed, besides the double nerve ring around the margin; usually designated as the central nervous system, a third ill-defined very

narrow nervous strand, peripheral to the above, around the margin; a definitely outlined radial system along the radial canals, both below the epithelial cells of the subumbrella as well as deeper beyond the muscle layer, in the flat epithelial endo-

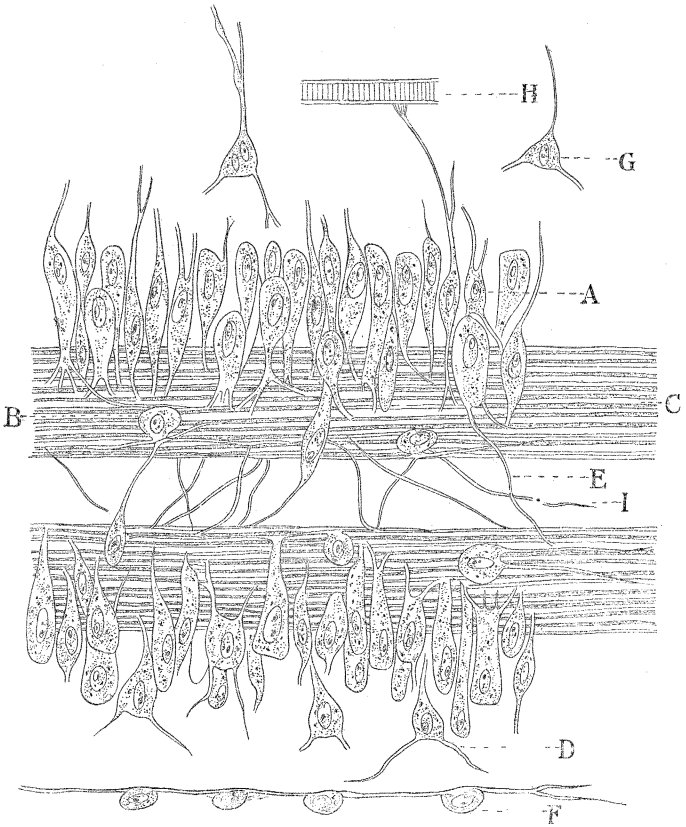

FIG. 1. Schematic view of a piece of the marginal nerve rings. Drawn from a study of many specimens studied with an oil immersion as well as lower power and camera lucida both from the sub- and exumbrella sides.

A, cells, transversely to the upper marginal ring.
B, ovoid cells with sheathed fibers.
C, nerve fibers parallel to the marginal ring.
D, multipolar cells proximal to the lower ring cells.
E, communicating fibers between the rings.
F, ovoid cells in the marginal strand.
G, multipolar cell of the subepithelial network.
H, muscle fiber.
I, space between upper and lower ring.

dermal layer; and a ganglionic and fibrous network beneath the epithelial layer of the subumbrella, which I believe sent nerve fibers beyond the endodermal flat epithelial-like cells, up to the gelatinous layer. The manubrium contains a ganglionic and fibrous network connected with large ganglia that lie along the radial area and smaller ones around its margin that send fibers to small sensory cells at its periphery, (Fig. 3).

A view from the exumbrella side of the margin of the animal discloses a narrow hyaline-like area between the marginal nerve rings (Fig. 1, *i*). It is along this line that the velum is attached. The upper nerve ring lies therefore above, the lower below the attachment of the velum. They are, however, not entirely distinct but are connected by communicating fibers that show most clearly, with proper focusing, from the subumbrella side (Fig. 1, *e*). The nerve rings are composed first of several rows of closely packed bi- and multipolar cells that lie tranversely to the nerve rings beneath the epithelial layer of the subumbrella (Fig. 1, *a*). They are very characteristic elongated cells with large nuclei. They usually taper at one end, more than at the other, and give off one or more fibers from the ends. Some of the fibers extend into the velum, some bend and run at a deeper level along with other nerve fibers around the margin, forming a double fibrous ring (Fig. 1, *c*). Some fibers extend into the other nerve ring, while still others extend toward the apex of the bell communicating either with the nervous network of the subumbrella, the radial nerves, or ending in muscle fibers. In addition to these snugly-packed spindle or ovoid-shaped cells, there are bipolar or multipolar cells, that lie at a deeper level in the fibrous portion of the ring canal (Fig. 1, *b*). The fibers emerge from the same side of the bulging or ovoid cells and extend in opposite directions among the fibers of the nerve ring (Fig. 1, *b*). At close intervals and proximal to the transversely situated cells of the lower marginal ring are, moreover, large multipolar cells that send fibers toward the periphery of the margin as well as into the nerve ring. A row of flattened ovoid bipolar cells form a third nerve ring of fibers and cells peripheral to those described above (Fig. 1, *f*). Pieces of tissue dissected from the umbrella in the region of the radial canals and exam-

ined both before and after removal of the genital glands, the cœlenteric canal or overlying gelatinous layer, show from the subumbrella side, at the border of the radial canal, closely arranged bi- and multipolar cells (Fig. 2, *k*, *j*) and focusing a little deeper a band of fine parallel nerve fibers intermingled with ovoid nerve cells that send off thicker fibers (Fig. 2, *j*, *l*). Focusing still

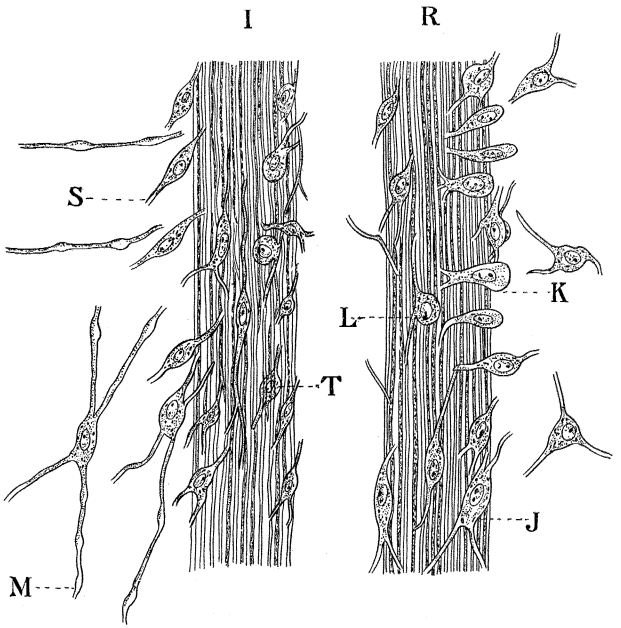

FIG. 2. Schematic view of a piece of the radial nerve tissue. The band at the right (*R*) represents the nerve cells below the ectodermal epithelium of the subumbrella; at the left (*I*) those between the muscles and the endodermal cells as seen from the exumbrella side.

J, multipolar cells, close to radial nerve fibers.
K, radial tissue cells.
L, ovoid cells among the radial nerve fibers.
M, beaded fiber of subepithelial network.

deeper, beyond the radial muscle fibers, somewhat smaller bi- and multipolar cells come to view (Fig. 2, *s*, *t*). The latter can best be seen from the exumbrella side. The first kind of cells lie below the ectodermal epithelium of the subumbrella. Some of their fibers extend laterally, seemingly to the muscles or the subumbrella network of ganglia and fibers (Fig. 2, *j*), others

go to the band of parallel nerve fibers and the nerve ring. These cells are more numerous in the neighborhood of the latter. Studied from the exumbrella side it was seen that the parallel nerve fibers lay close to the radial muscle fibers, and that besides the bi- and multipolar cells beneath the ectodermal epithelium, there were other, smaller, bi- and multipolar cells, situated between the muscle layer and the endodermal epithelium.

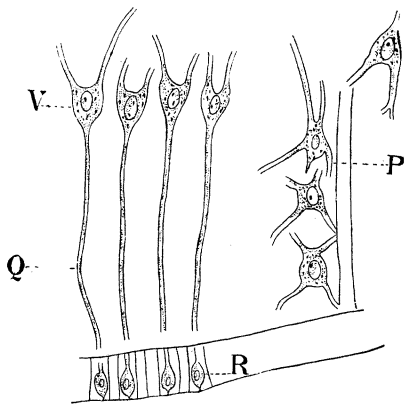

FIG. 3. Schematic view of nerve cells in a piece of the manubrium from its margin in the radial region.

P, multipolar cells in radial region of manubrium.
Q, fibers from multipolar cells at border of manubrium.
R, sensory cells in epithelium of manubrium.
V, multipolar cells at the border of manubrium.

The fibers from these cells seem to go to the genital glands, the cœlenteric canal and narrow band of muscle fibers beneath the radial cœlenteric canal, as well as into the parallel layer of nerve fibers. It may be that these are especially concerned with the digestive and reproductive systems.

In addition, therefore, to the marginal nerve ring and the radial nervous system, there is the peripheral network of cells and fibers that exist beneath the epithelium of the subumbrella. The cells of this network are triangular and multipolar with sheathed fibers that have slight thickenings at different places in their extent. Some lie close to the radial (Fig. 2, *m*), others to the marginal nerve bands (Fig. 1, *g*). Then, too, in a line midway be-

tween the radial nerves, the cells lie radially closer, sending some of their fibers up to the gelatinous layer. This net-work thus serves as a connecting link between the radial and marginal nervous structures. The manubrium also has its network of cells and fibers and along the margin of the manubrium is a row of large multipolar cells (Fig. 3, *v*) that send fibers to the periphery where they join special sensory cells that lie among the epithelial cells (Fig. 3, *r*). In the radial region of the manubrium are larger closely set nerve cells. It was seen that fibers from the nerve rings extend to the tentacles and sense organs, and that the latter contained most peculiar nerve tissue. To understand that and the endings of the different nerve fibers, requires detailed histological study of sections of the various regions of the body. This I hope will be done in the near future.